Fabry-Perot Interferometer for Column CO_2

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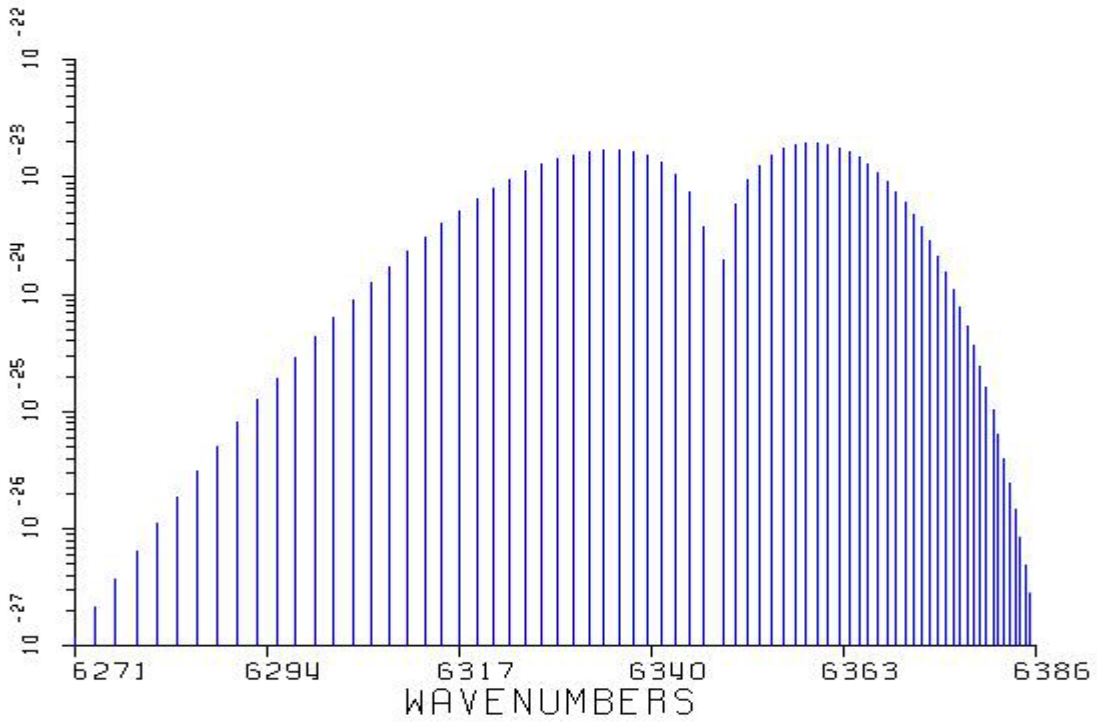
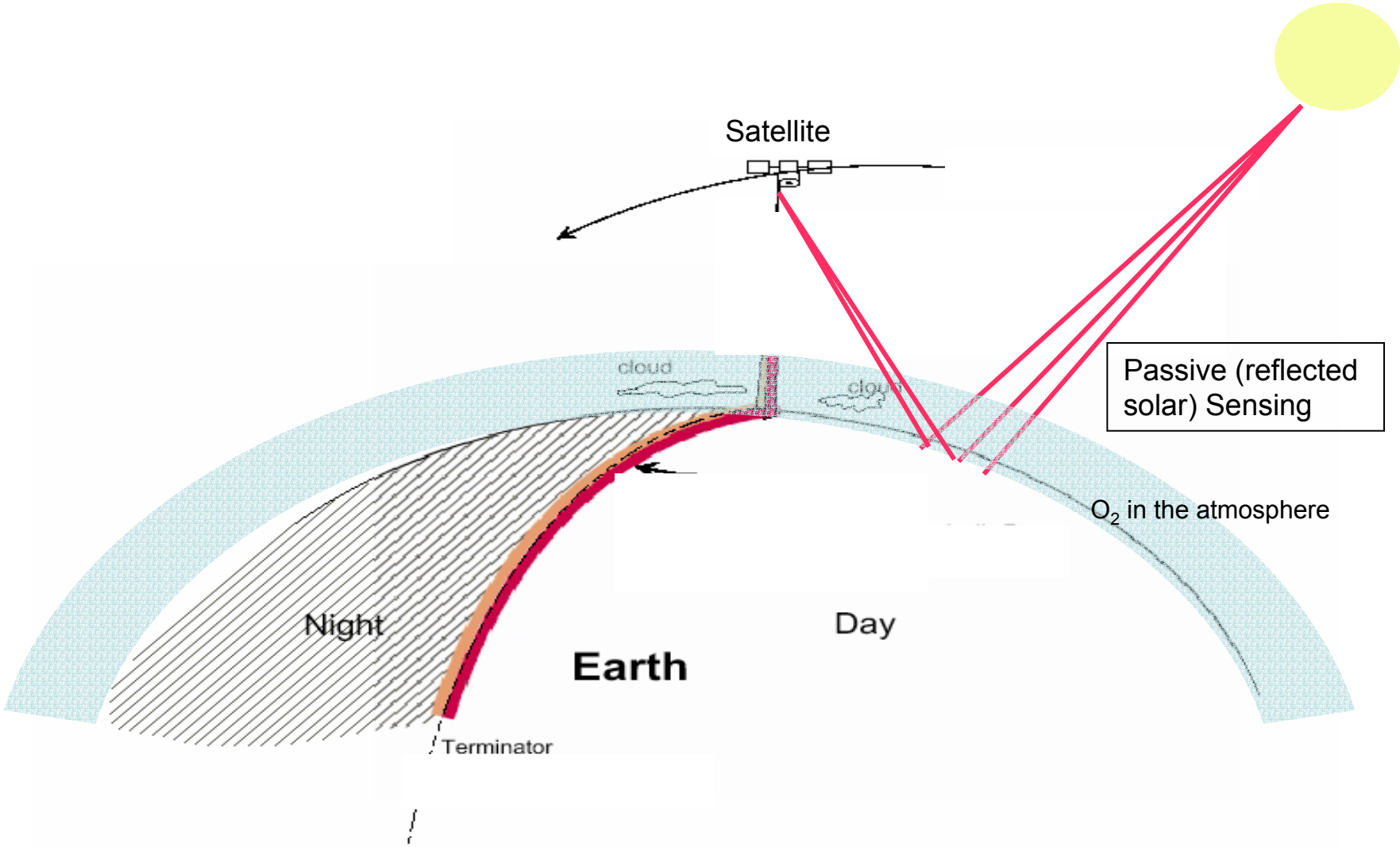
Objective

To construct a prototype instrument for deployment on aircraft that will demonstrate the feasibility of an innovative technique for measuring column average CO_2 from space with precision >.3%

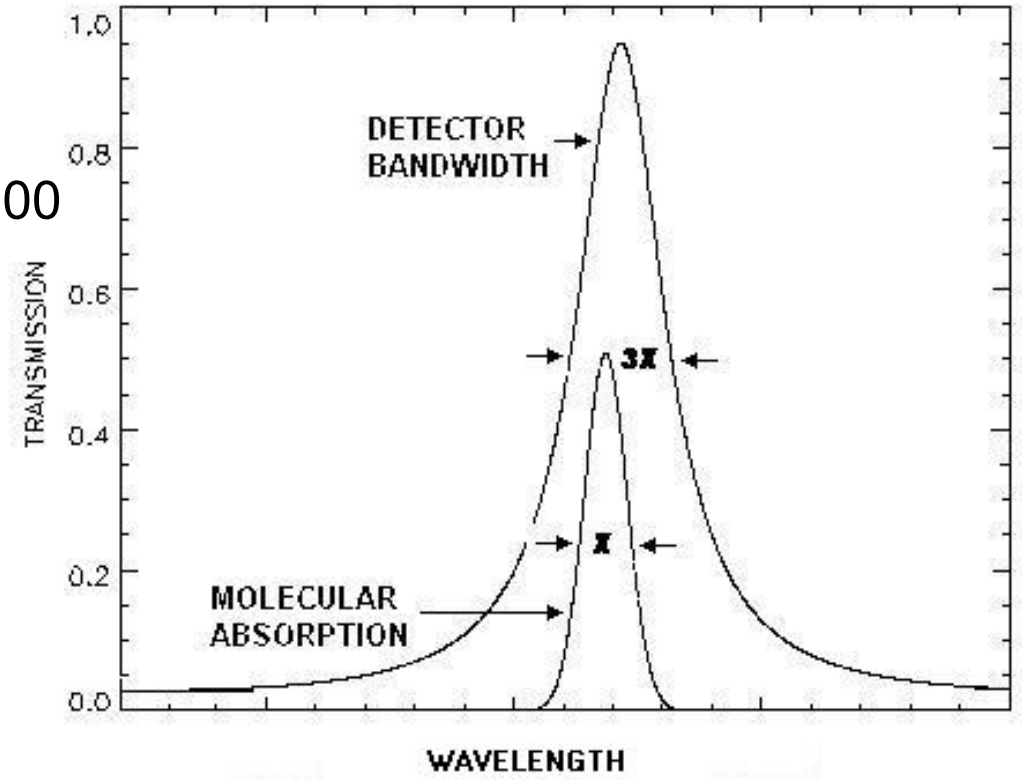


Space-based Measurement Approach



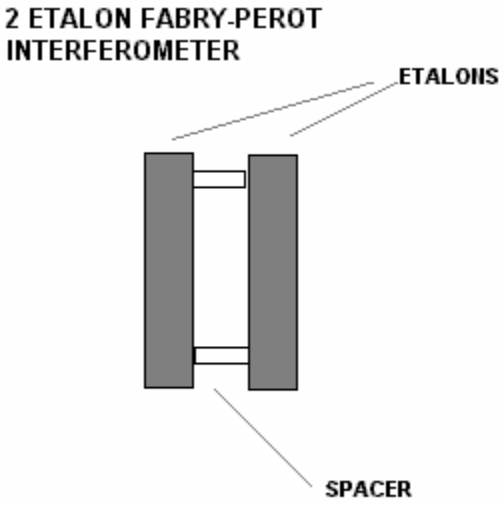
Motivation

- TYPICAL CO_2 LINEWIDTH ~ 40PM
- IMPLIES RESOLUTION ~35000
- PRECISION >0.003 REQUIRES BIG SIGNALS
- FOR A GRATING SPECTROMETER THIS MEANS A **BIG** INSTRUMENT



Matching Bandpass to Linewidth

AN INTERFEROMENTER HAS MUCH GREATER LUMINOSITY FOR ITS SIZE THAN A GRATING WHEN OPERATED AT EQUAL RESOLUTION. THIS IS CALLED THE JACQUINOT ADVANTAGE.

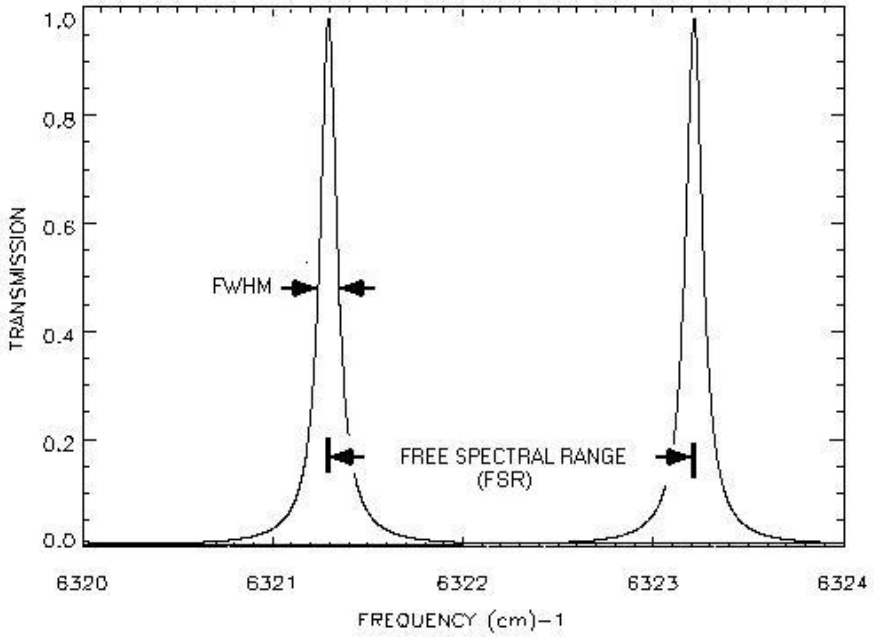


FABRY-PEROT IS ONE OF THE SIMPLIST TYPES OF INTERFEROMETER.

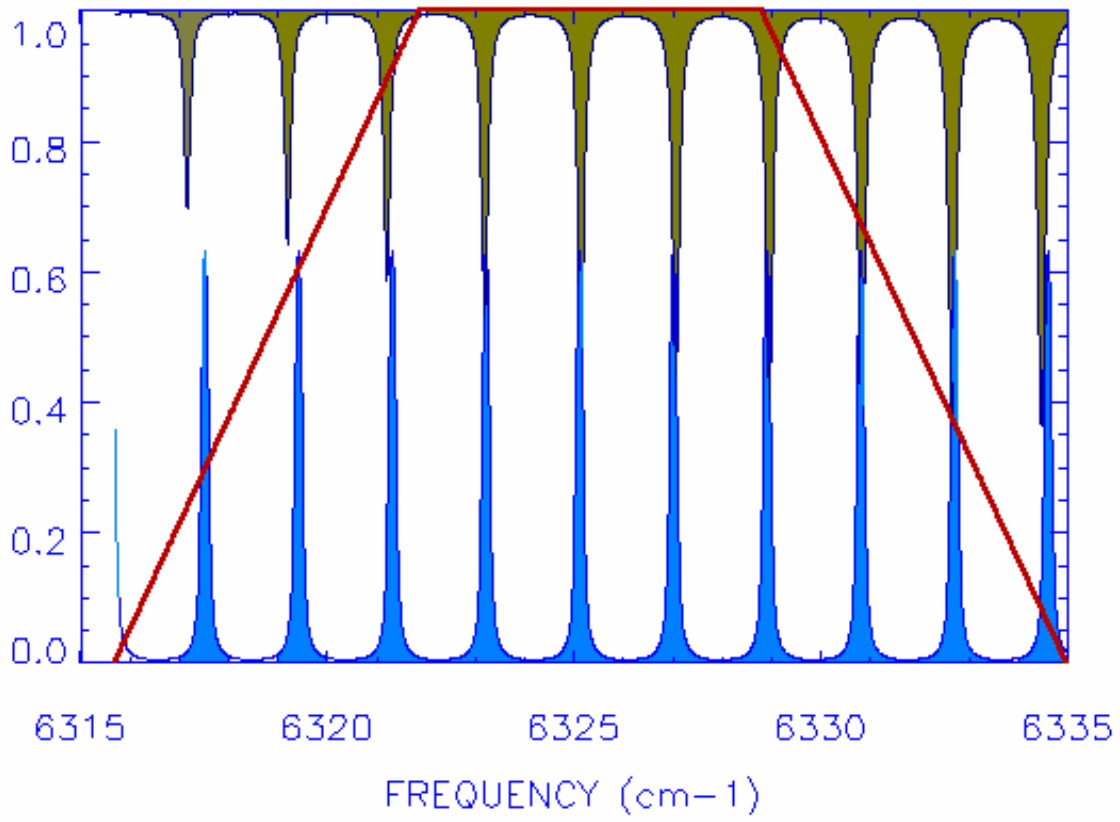
$n\lambda = 2\mu l \cos \phi$

FSR= $1/(2\mu l \cos \phi)$

finesse = FSR/FWH $= \pi R\ 1/2/(1-R)$



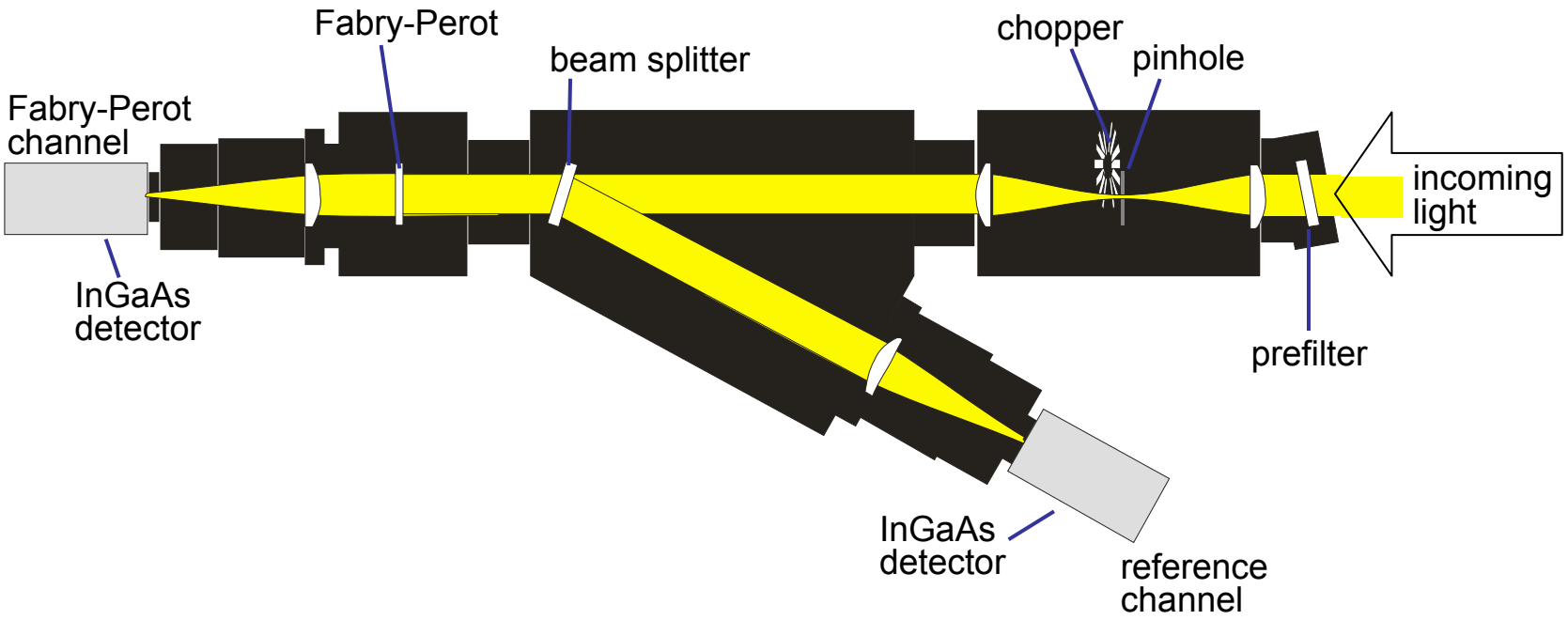
Modeled Overlap of Fringes and CO_2 Lines



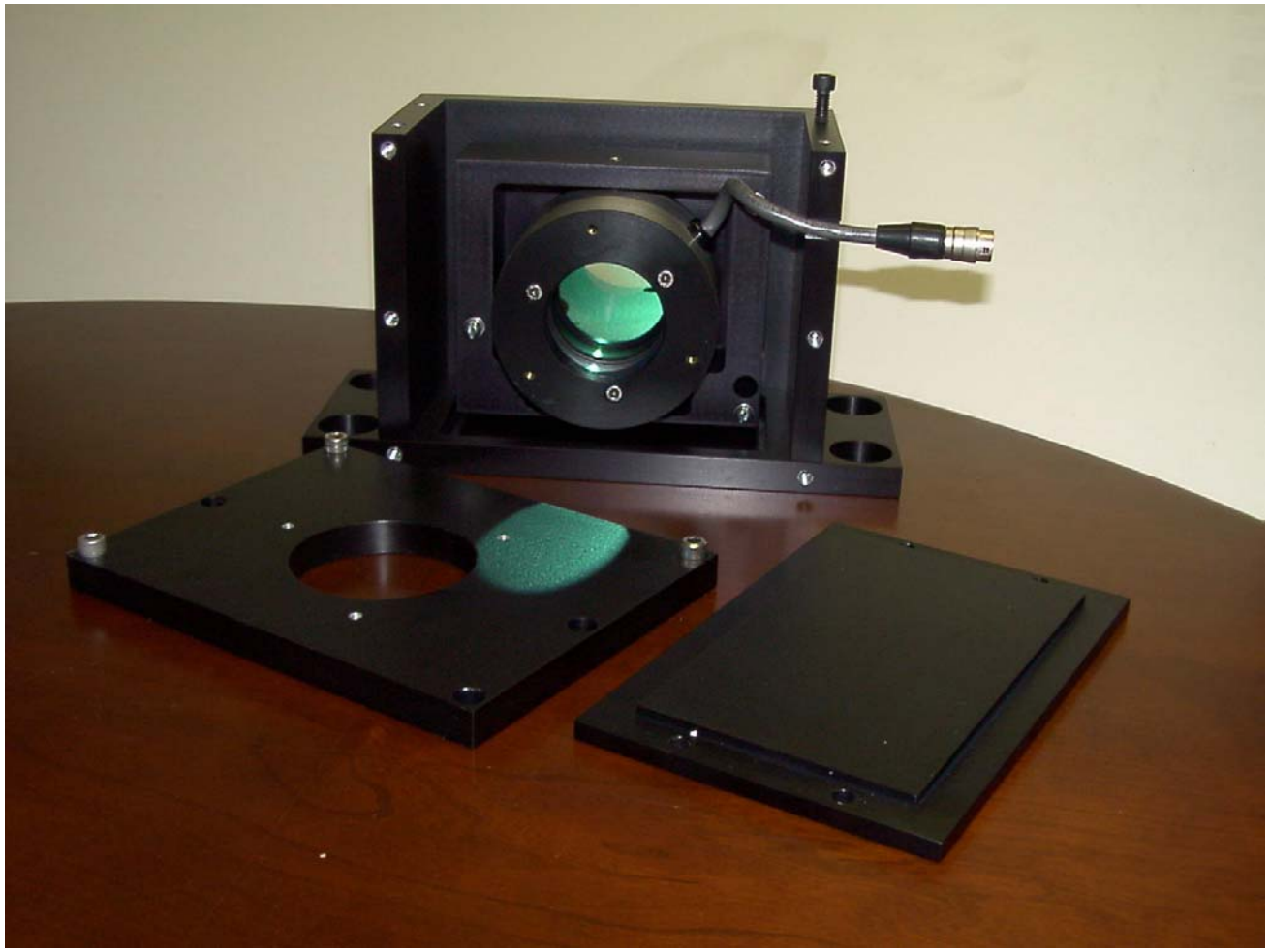
FUSED SILICA FP ETALON .191 CM THICK REFLECTIVE FINESSE=10

SENSITIVITY=1565

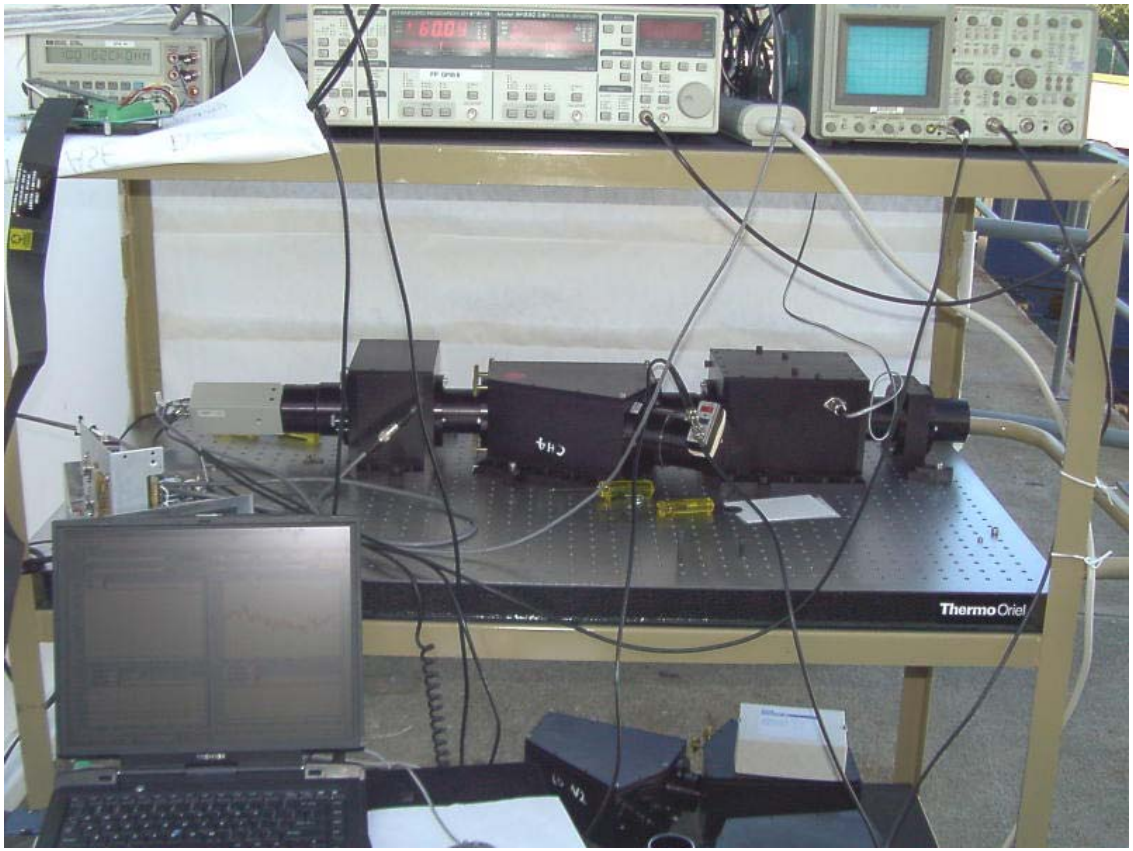
Instrument Design



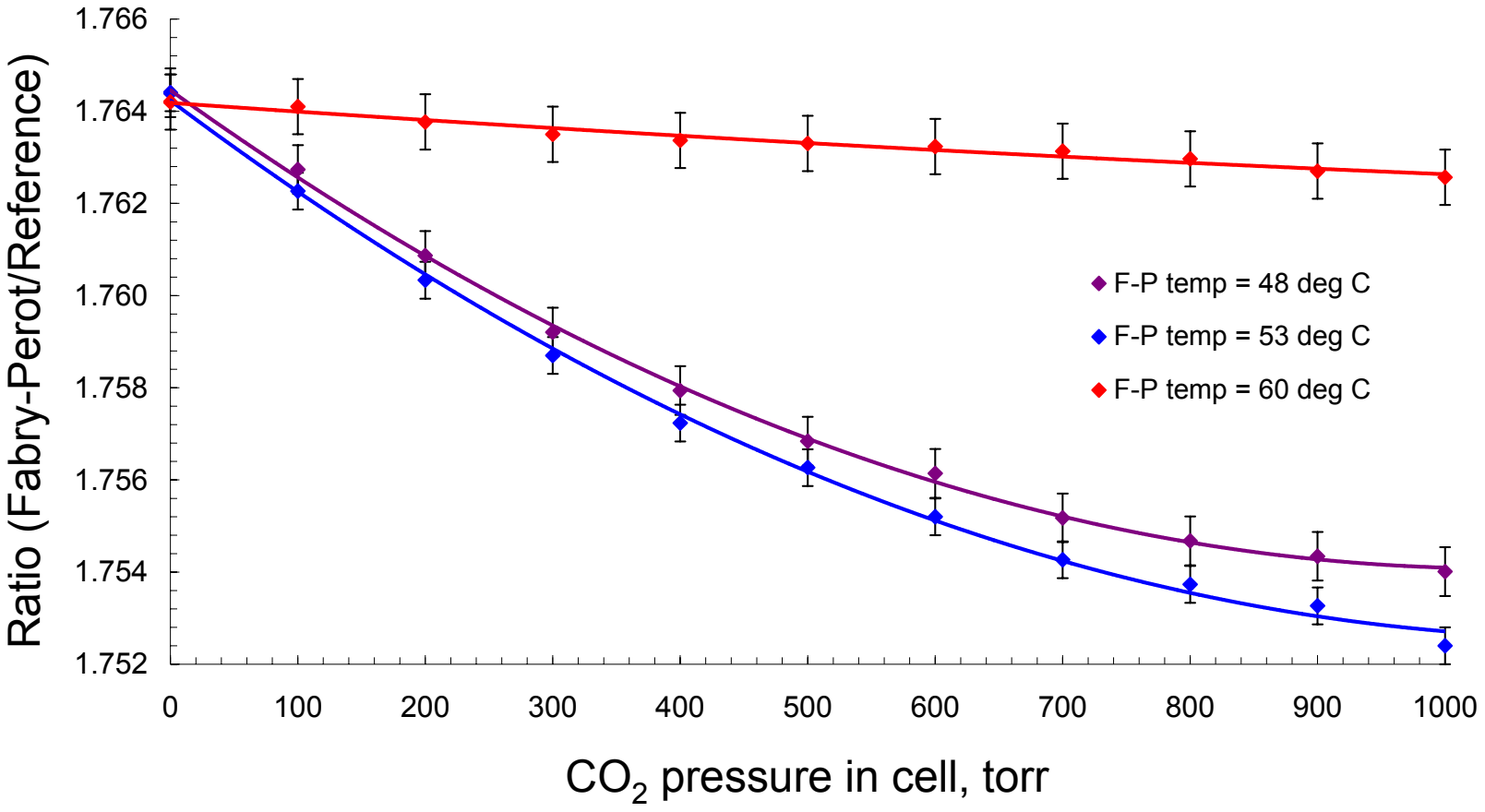
Solid Fabry-Perot etalon in oven and optical mount



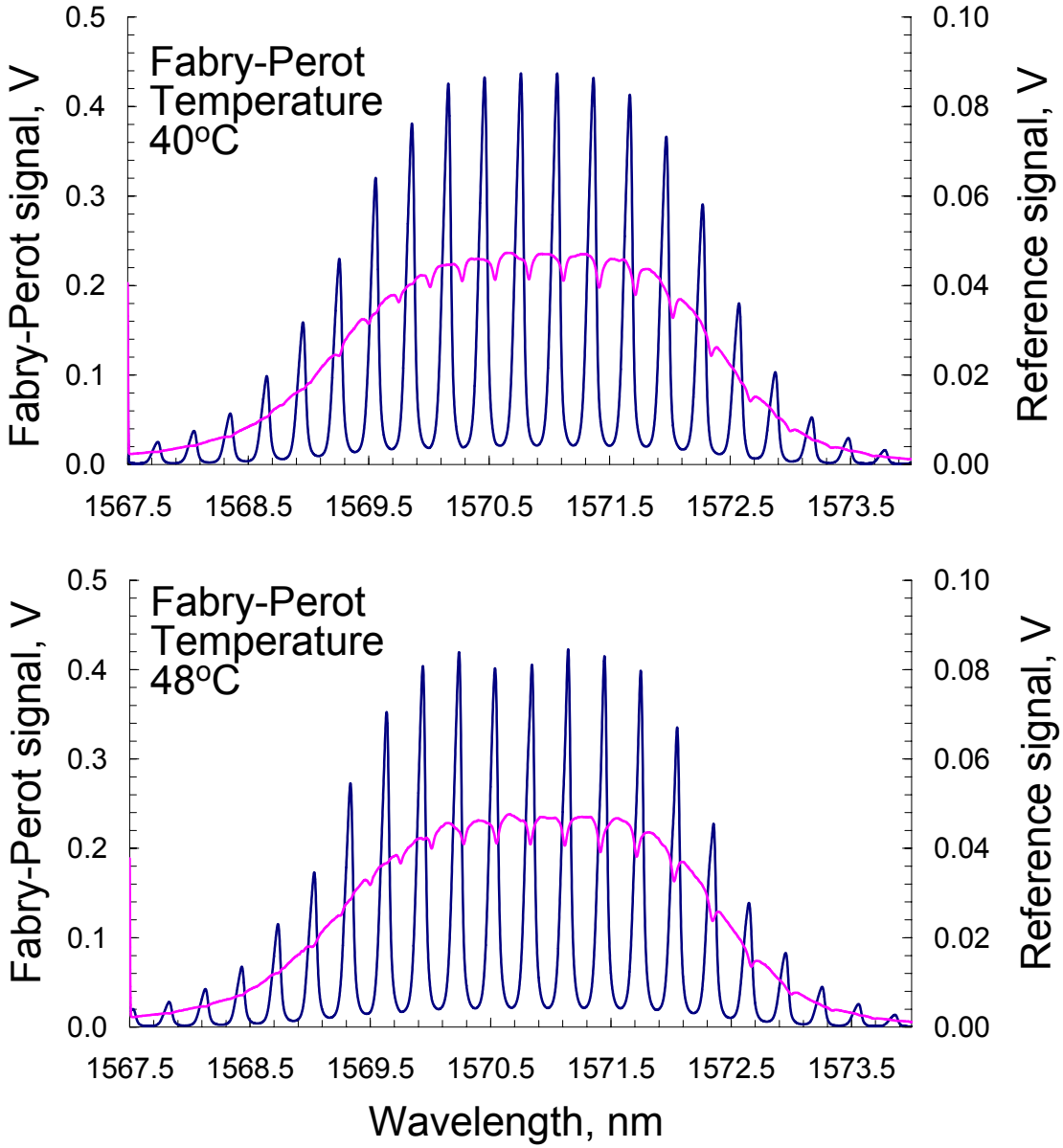
Laboratory Prototype



Ratio as a Function of CO_2 Pressure

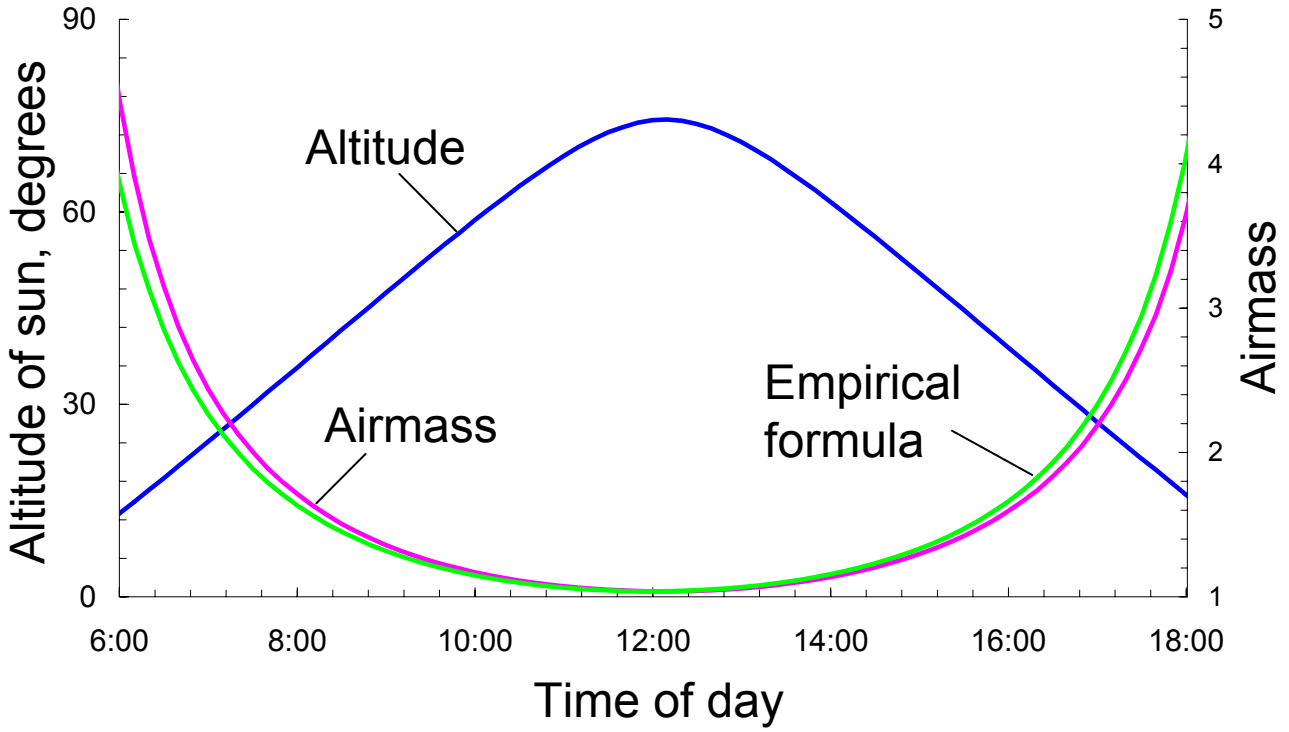


Comparison of Overlap at Two Temperatures



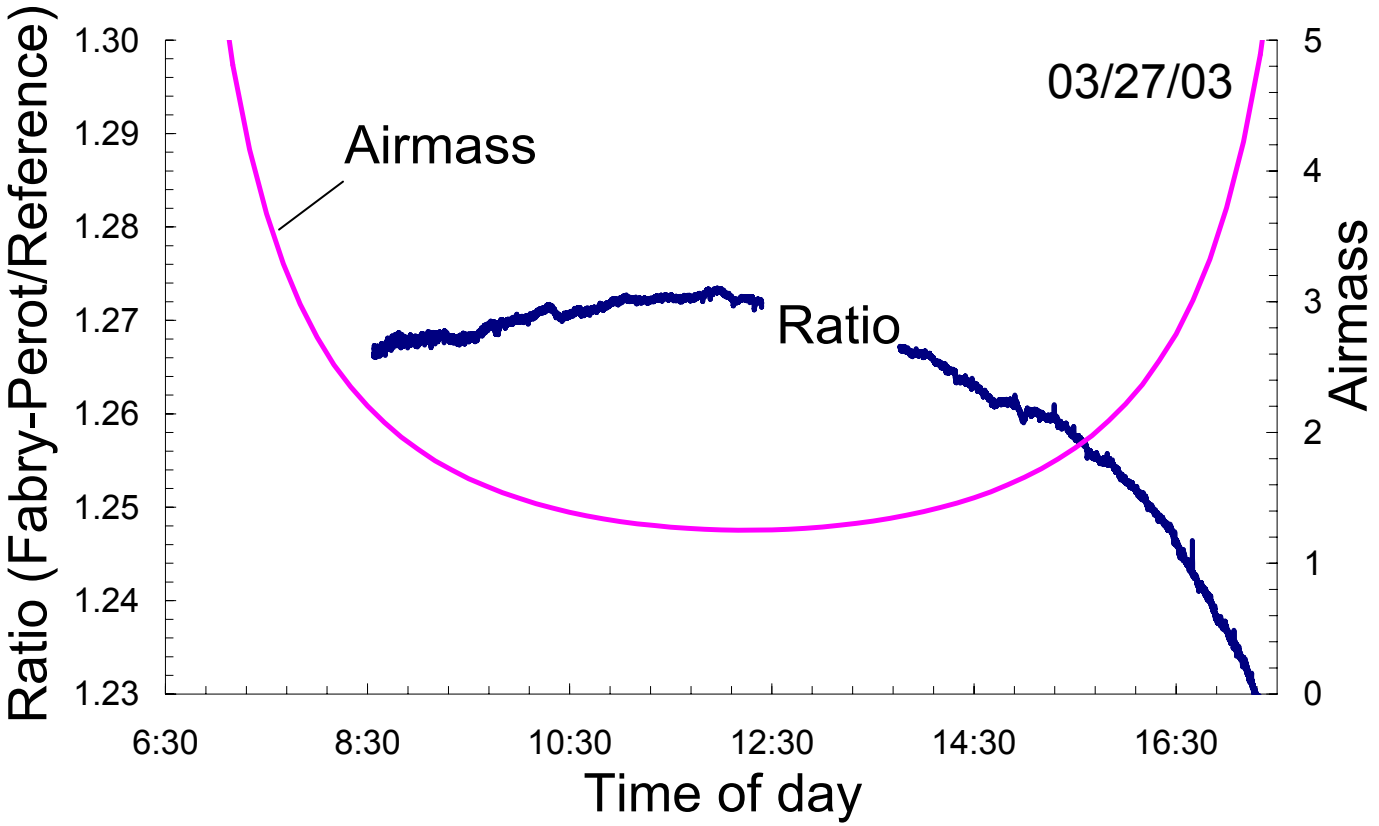
Ground Testing

Altitude and Airmass

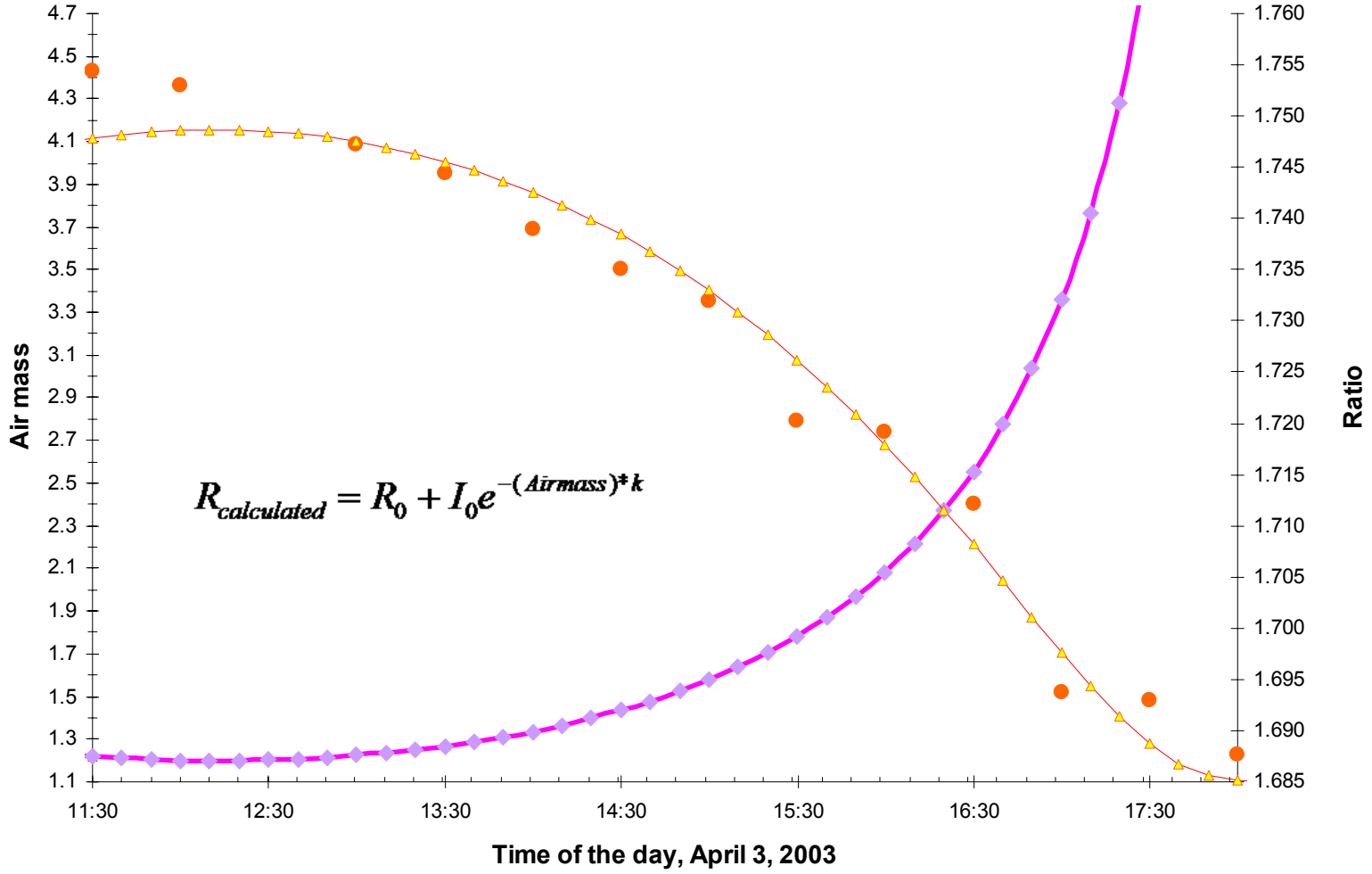


- Altitude data for June 16, 2003 in Greenbelt, MD Astronomical Applications Department US Naval Observatory, Washington, DC 20392-5420
- Airmass = $\sec\left(\frac{\pi}{180}\left(90 - altitude\right)\right)$ $ALT = altitude(radians)$
- Airmass$\begin{pmatrix} Empirical \\ formula \end{pmatrix} = 1229 + \left(614 \cdot \sin(ALT)^2\right)^{1/2} - \left(614 \cdot \sin\left(ALT\right)\right)$

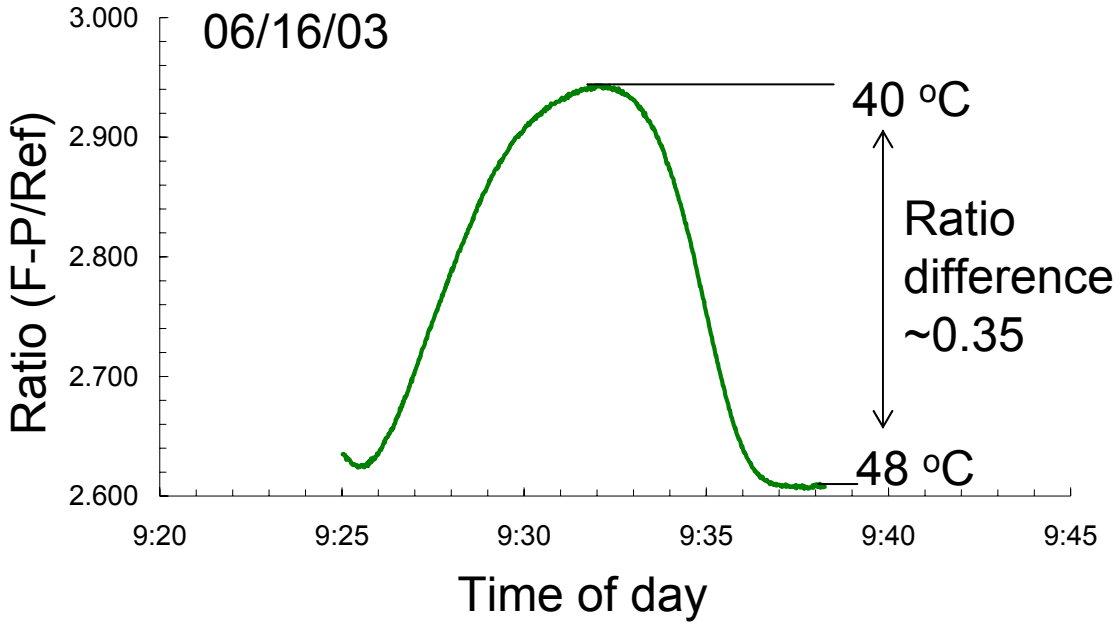
Preliminary Data



Direct Sunlight Data

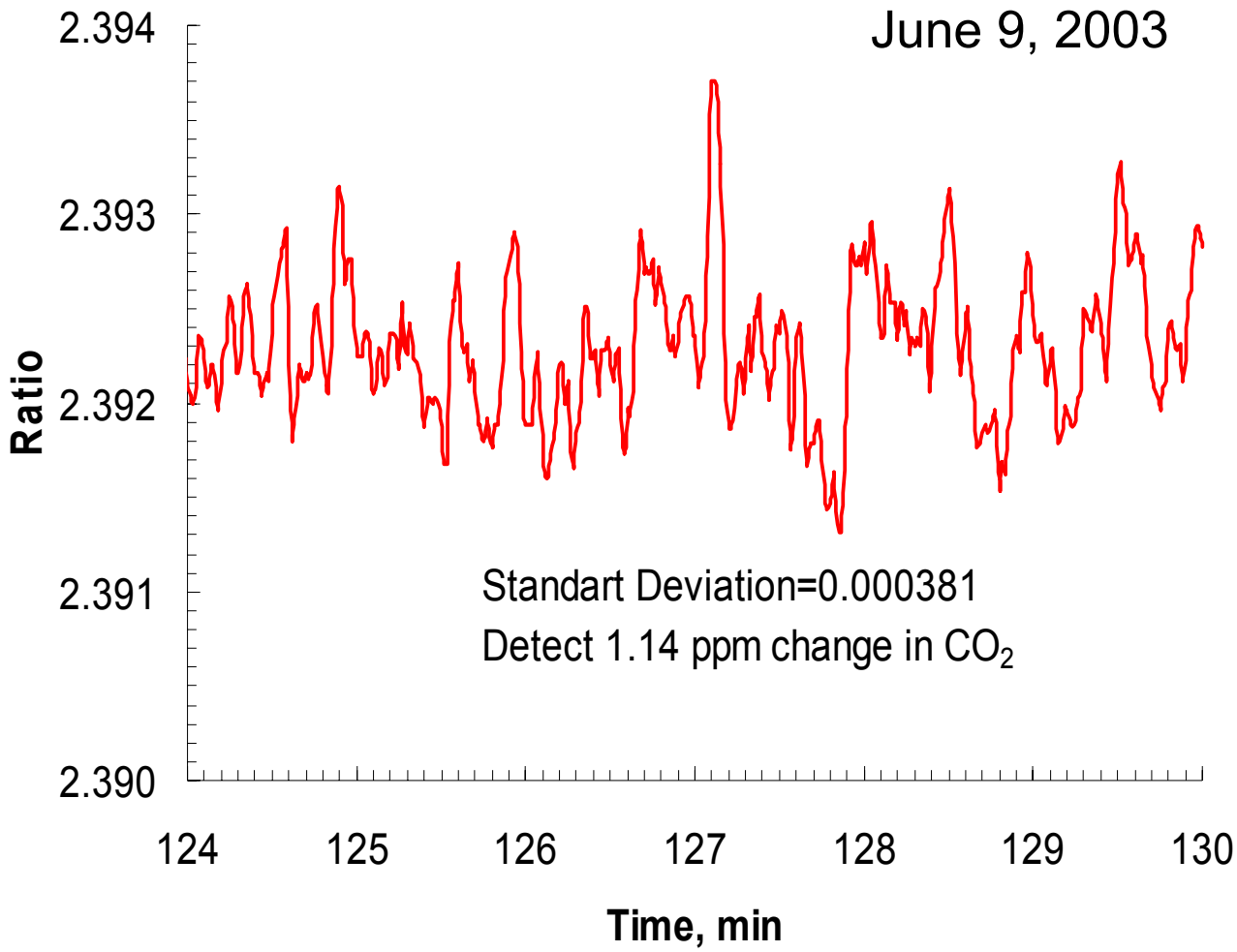


Sensitivity Estimate

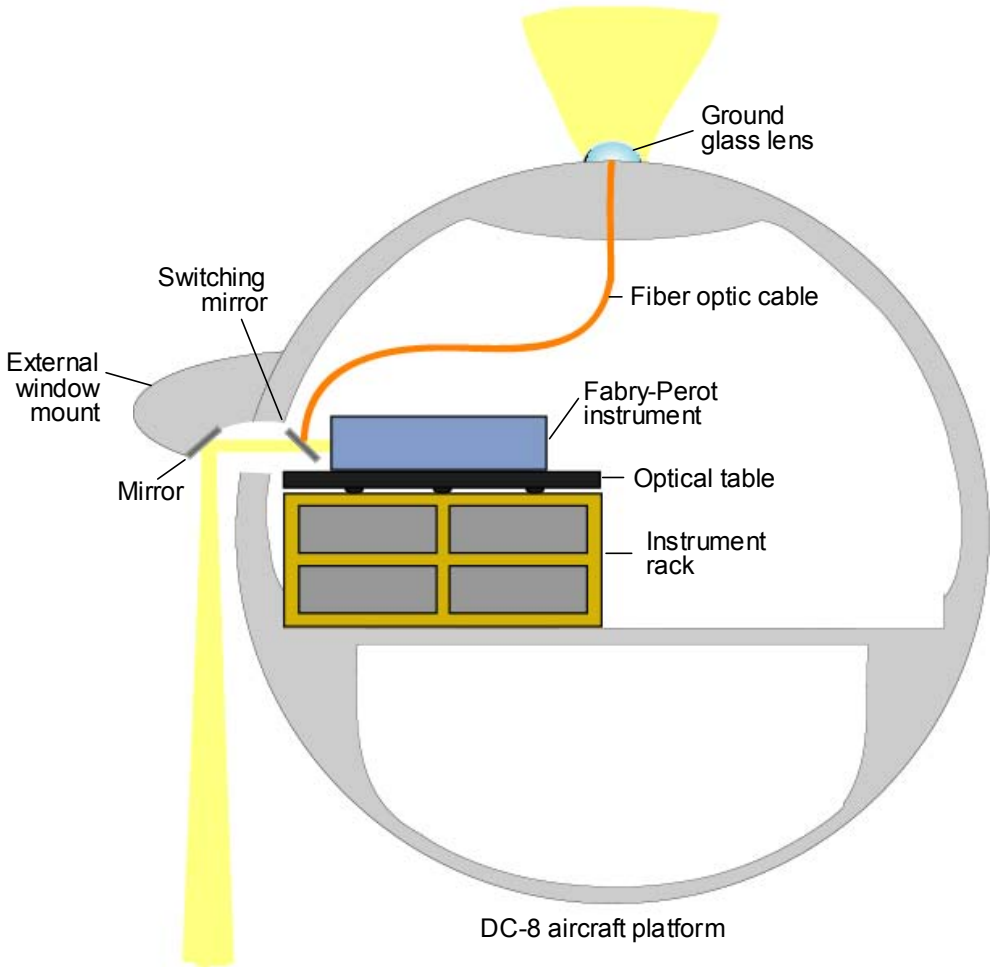


- At time of F-P temperature scan, airmass ≈1.2
- CO_2 in atmosphere is 360 ppm
- 1.2 x 360 ppm ≈ 430 ppm
- Ratio changes 0.35 for 430 ppm
- Thus, sensitivity to 1 ppm change is 0.35/430 = 0.0008

Detection Limit Estimate



DC-8 Aircraft Platform



Summary & Status

- FABRY-PEROT BASED SYSTEM FOR CO2 COLUMN MEASUREMENT IS UNDER DEVELOPMENT AT GSFC
- PERFORMANCE OF PRINCIPAL COMPONENTS HAS BEEN VERIFIED
- SENSITIVITY CONSISTENT WITH EXPECTATIONS ~1.2 PPM WITH 2:1 SNR IN ONE SECOND OF AVERAGING AT PRESENT
- InGaAs DETECTOR WITH LOWER NOISE IDENTIFIED
- DESIGN NEARING FINALIZATION
- DIFFERENTIAL SENSITIVITY (ie. CALIBRATION) MEASUREMENTS ABOUT TO BEGIN
- AIRBORNE SYSTEM TO BE EVALUATED IN ABOUT 1 YEAR

Summary & Status (continued)

- F-P's FOR O2 CHANNEL (USED FOR NORMALIZATION) EXPECTED IN 2-3 WEEKS. OTHER PARTS IN HAND.

- EXTENSION TO OTHER SMALL MOLECULES LOOKS PROMISING

- POTENTIAL FOR SMALL, SIMPLE SYSTEM WITH EASY ADAPTATION FOR SATELLITE USE

Acknowledgements

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